

# NASTRAN DATA GENERATION AND MANAGEMENT USING INTERACTIVE GRAPHICS\*

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## SUMMARY

For effective use of NASTRAN, the input bulk data must accurately model the structure to be analyzed and result from a minimum of time and money expended. A method of using an interactive graphics device to generate a large portion of the input bulk data with visual checks of the structure and the card images is described. The generation starts from GRID and PBAR cards. The visual checks result from a three-dimensional display of the model in any rotated position. By detailing the steps, the time saving and cost effectiveness of this method may be judged, and its potential as a useful tool for the structural analyst may be established.

## INTRODUCTION

The generation of NASTRAN input bulk data to correctly simulate or model a large structure to be analyzed usually consumes many man hours and much time. Sketches and/or drawings are necessary to define the GRID numbers connected by structural elements identified with EID numbers and their property identification PID numbers. After the constraints are organized, a list for keypunching must be prepared. After the cards are keypunched and inputted to the computer, more time is required to debug the input data for compliance with the NASTRAN formats before an answer is outputted. Debugging procedures usually employ plotting capabilities available in NASTRAN to provide visual checks of the structural model. Normally, further checking follows by noting values in the load vectors generated by gravity loadings, the coordinates of the center of gravity, and symmetry or equating of the single-point constraint values to the input load vectors.

Besides the schedules time deadlines, the total cost of the analysis must be considered. Procedures or processes that can reduce the time of preparing input data invariably reduce costs. If during these processes the correctness of the model can be raised to a high level before input to a computer, the NASTRAN computing costs can be reduced.

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\* This paper presents the results of one phase of research carried out at the Jet Propulsion Laboratory, California Institute of Technology, under Contract No. NAS 7-100, sponsored by the National Aeronautics and Space Administration.

At JPL, with the installation of the UNIVAC Advanced Graphics Display System to the UNIVAC 1108 — EXEC 8 time-sharing computer used for scientific computing purposes, the development of the use of interactive graphics to generate and check NASTRAN bulk data has proceeded.

## CONFIGURATION DESCRIPTION

The UNIVAC Advanced Graphics Display System is composed of two major units: the display controller minicomputer (Type 1557) and the display console (Type 1558). The purpose of the minicomputer is to provide computing and control capabilities to handle, internally, display functions and programs that are tailor-made by the user to meet NASTRAN bulk data requirements. It also serves as an interactive device to the UNIVAC 1108 processor to provide additional large-scale processing capabilities.

The display console consists of a cathode ray tube (CRT) display, keyboard, display control, and light pen. The unit is designed for display of grid points, line vectors, alphanumeric characters, and special symbols necessary for the NASTRAN program. It features a high-speed, high-precision CRT to accommodate the wide variety of graphic displays.

The basic configuration of the system interfaces directly with an input/output channel of the UNIVAC 1108 processor. The basic storage for the minicomputer contains 8192 locations.

## GRAPHICS PROGRAMMING LIBRARY

A primary purpose of the UNIVAC 1108 — EXEC 8 computer and Graphics Programming Library (GPL) is to provide easily manipulated data structures that describe and define a displayable image for the 1557/1558 graphics minicomputer/display console.

The GPL permits both the graphics entities which constitute the images to be displayed and nongraphic associated or managerial data to be defined and stored in the data base. Entities of both types can be grouped to form single higher level or parent groups capable themselves of being grouped to form still higher-level groups, giving rise to a hierarchically organized data structure.

A large central data base is required to support the NASTRAN package; thus many automatic facilities are included in the system to make management of this data both convenient and efficient. In order to maintain the integrity of the data file, it is accessible only through the GPL subroutines. These subroutines permit total flexibility in defining, manipulating, and displaying images on the display screen.

Interaction control tables (ICTs) provide a unique approach to the problem of defining and accomplishing the processing to be performed in the

minicomputer. These tables handle the function of basic attention handling, analyze and change both its data base and display file, and send and request information to and from the central computer as required. The ICTs are a hardware-independent, interpretively executed, interactively oriented language in which processing performed by the minicomputer is programmed by the user.

## THE USE OF INTERACTIVE GRAPHICS

### Structure Development Program

In the normal analysis, the preparation of the input bulk data cards starts with the GRID cards. The grid point numbers of these cards are defined on a sketch or drawing. Also, from these pictures the coordinate values are ascertained directly or by calculations on a desk machine. Normally, these coordinate values are described within the precision limits of the computer, although in the real structure there are larger errors. These errors can be evaluated as to their effects on the answers from the analysis as one more separate problem in structural analysis to be considered. Because of the symmetrical nature of many structures, precise coordinate values usually aid in debugging as well as enhancing the use of partial section analysis, thereby reducing the time and cost of analysis.

For this method of interactive graphic adaptation, the GRID cards are keypunched to suit NASTRAN format. For this discussion we will assume that only CBARs are used, so PBARs are keypunched next.

At this point, these NASTRAN cards are input to a catalog file in the 1108, and the 1557/1558 unit through GPL is activated so that the CBARs can be generated or completely listed and keypunched for observation and updating by interactive graphics. The NASTRAN graphics package consists of three subprograms: a structure development subprogram for the CBAR generation, a rotation subprogram for visual demographics, and a data edit subprogram for card image alterations. Each subprogram can be used in a stand-alone mode or can be subroutinized to operate interchangeably.

The graphics tube face layout has been designed from a human engineering standpoint, with speed and efficiency coordinated at each user/hardware operation. The tube face is divided and overlayed by windows, each representing a segment of the visual data structure. One window contains a "menu" which informs the user of his current status in the program. These window and menu concepts can be seen in figure 1.

In the left window, the grid point identification numbers from the catalog file are listed in columns. Above it are listed the PID numbers of the PBARs. To the right side of the grid ID, there is space for displaying the generated CBAR data.

The right window of the tube displays, as point vectors, the grid point locations initially as they appear normal to the XY plane. Then by pressing either X, Y, or Z on the keyboard, the views in XY, XZ, or YZ planes, respectively, can be displayed.

The light-sensitive pen is then pointed to the first GA of the desired CBAR. The screen responds by displaying a  $\pm$  "local indicator" next to the listed GA as well as the point vector on the right window. When in succession, the GB, PID, and GO are selected via light pen interaction; then a "C" in the keyboard enters the CBAR, which is shown by an entry in the CBAR connection list data in the left window and a directional vector between the point vectors of the GA and GB. The formats described are shown by a photograph of the screen after some CBARs have been developed (fig. 1).

At any time during this development of the structural model the rotation subprogram may be called and the model can be visually checked from any oblique angle. Figure 2 shows the model of figure 1 viewed by rotations around the X and Z axes of 30 degrees each. Figure 3 shows the complete development at a -30 deg angle about the X axis.

#### Rotation Subprogram

This monitor (a 1557 software operating system) performs three-dimensional rotation on the two-dimensional screen, which gives the user complete control of visual structure demographics: rotation about any axis, at any incremental angle, at any speed. This combination of control leads to "animated" movement in three dimensions for visual analysis and to hard copy graphics of the structure.

If at this time the card images of a GRID or CBAR require changes, the grid data may be edited by a call to the data edit subprogram. A typical display is shown in figure 4. By use of the keyboard, specific changes can be made in the card image inputs.

#### Data Set Edit Subprogram

The data set edit routine can be utilized as a stand-alone procedure to update an existing NASTRAN data package or as a subroutine in a structure development production.

The data set edit routine presents the "card image" run stream by paging data and control messages across the screen at the user's discretion. On each page, the user has control or editing options and can direct the program direction. The user can change a card image, delete a card image, and add a card image which represents a CBAR or PBAR, while maintaining all structure credibilities connected to the member unless entirely deleted.

The user can switch the rotation monitor on and visually check his structure, flag a member, and automatically have the program page to the card image representing the member for further analysis and editing.

To prevent loss of completed connections a page of 25 CBARs is automatically stored in the user's FASTRAND file. In turn, the next 25 CBARs may be entered. This program has restart capabilities in case of computer failure or "current" analysis changes.

When the visual checks of the interactive graphics output signal a good set of GRID, CBAR and PBAR cards, the final exit can be made by requesting the 1108 to punch out the edited cards as presently programmed, or, in the 1108, it is possible to have data files read into a catalog file so that an immediate NASTRAN run can be made from the remote terminal used for the 1557/1558 unit.

### ADVANTAGES OF INTERACTIVE GRAPHICS

The replacement of the normal listing of CBARs and subsequent keypunching with the use of interactive graphics will save time. However, the greatest values should result from the opportunity to make intermittent three-dimensional visual checks of the structural model. The analyst can insure the accuracy of the model as well as provide an opportunity for study to optimize the geometric arrangement.

As the system is now working, using many satellite ICT routines and self-contained monitors with the minicomputer, minimum demand time is required of the 1108. The current cost of working the system is approximately \$50/hr. This includes "roll-in/roll-out" of the three monitors and full user utilization in a demand environment.

### ACKNOWLEDGEMENT

Appreciation is expressed to Larry Bauer of UNIVAC for advanced developments of the GPL and to Robert Patton for research and development of the rotation subprogram.



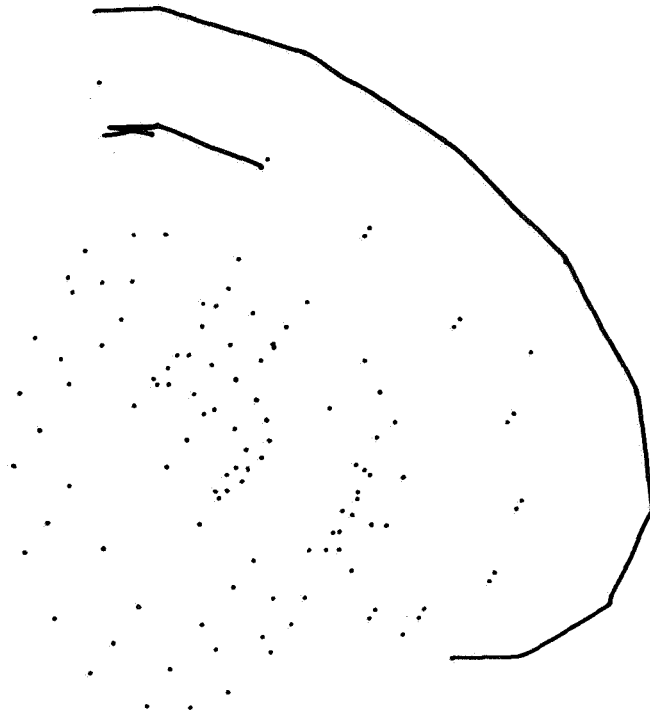


Figure 2. -Rotated partial development, rotation subprogram

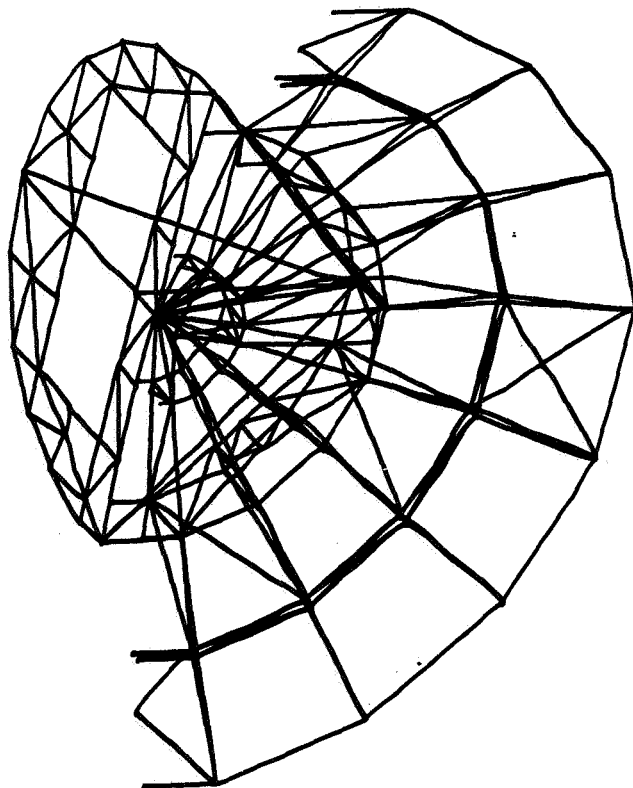


Figure 3. -Rotated full structure, rotation subprogram

CBAR	EID	PID	GA	GB	G0	F
*CBAR	61	35	20	22	19	2
*CBAR	44	35	19	21	22	2
*CBAR	65	35	20	42	33	2
*CBAR	69	35	21	33	42	2
*CBAR	129	35	42	49	33	2
*CBAR	107	35	33	50	42	2
*CBAR	152	35	49	64	77	2
*CBAR	156	35	50	64	76	2
*CBAR	157	35	50	77	76	2
*CBAR	199	35	64	77	76	2
*CBAR	198	35	64	76	77	2
*CBAR	238	35	76	106	77	2
*CBAR	243	35	77	107	76	2
*CBAR	308	35	106	115	116	2
*CBAR	310	35	107	116	115	2
*CBAR *****						
<div> <div>* OLD PAGE</div> <div>* NEW PAGE</div> </div> <div> <div>* LIST</div> <div>* RETURN</div> </div>						
PL						

Figure 4. -CBAR listing, data set edit subprogram